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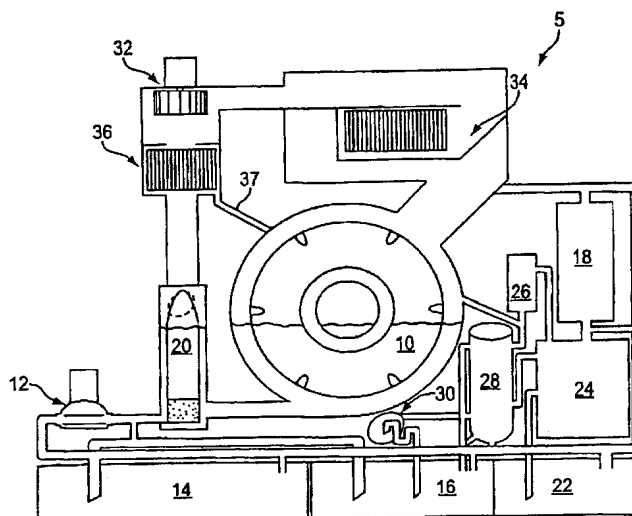
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— With international search report.
— With amended claims.
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DRY CLEANING APPARATUS AND METHOD CAPABLE OF UTILIZING A SILOXANE COMPOSITION AS A SOLVENT



(57) Abstract: A system and method are provided for dry cleaning articles utilizing a siloxane solvent. The system (5) includes a cleaning basket (10) for receiving articles therein and one or more tanks (14, 16) for containing a siloxane solvent. Coupled between the tank and the cleaning basket is a pump (12) for immersing the articles in the cleaning basket with the siloxane solvent. Also included is a still (24) for distilling the dirty siloxane solvent to recover the pure siloxane solvent. A condenser (26) is coupled to the cleaning basket and/or the still for recovering condensed vapors. For decanting any water in the siloxane solvent received from the condenser, a separator (28) is coupled to the condenser. A fan (32) is coupled to the cleaning basket for circulating air past the condenser, then the heater coils (34) and into the cleaning basket for drying and cooling the articles.



WO 01/48297 A1

PERC, but are still classified as volatile organic compounds (VOC's). As such, such compounds are regulated and permitted by most air districts.

5 The dry cleaning industry has long depended on petroleum-based solvents and the well-known chlorinated hydrocarbons, perchlorethylene and trichlorethylene, for use in the cleaning of fabrics and articles of clothing. Since the 1940's, PERC was praised as being a synthetic compound that is non-flammable and has great degreasing and cleaning qualities ideal for the dry cleaning industry. Beginning in the 1970's, PERC was found to cause liver cancer in animals. This was an alarming discovery, as dry cleaning waste was placed in landfills and dumpsters at
10 that time, from which it leached into soil and ground water.

Environmental Protection Agency regulations gradually were tightened, culminating in a law that took effect in 1996 that required all dry cleaners to have "dry to dry" cycles, meaning that fabrics and articles of clothing go into the machine dry and come out dry. These required
15 "closed loop" systems that can recapture almost all PERC, liquid or vapor. The process "cycle" involves placing fabrics or articles of clothing into a specially designed washing machine that can hold 15 to 150 pounds of fabrics or articles of clothing that are visible through a circular window. Prior to being placed into the machine, the fabrics or articles of clothing are checked and treated by local hand spotting for stains. If the fabric is unusual or known to be troublesome,
20 the label is checked to verify that the manufacturer has deemed the item safe for dry cleaning. If not, the stain may be permanent. As an example, a sugar stain may not be seen, but once it is run through the dry cleaning process, it oxidizes and turns brown. If the stain is grease related, water won't help, but solvent will as it solubilizes grease. In fact, the principle reason for dry cleaning certain clothes (which should not be washed in a regular washing machine) is to remove the
25 build up of body oils (known as fatty acids) because they too oxidize and produce rancid nasty smells.

The grease and fatty acids which build up in the solvent is removed by filtration and by distillation of the solvent. In other words, the dirty solvent is boiled and all vapors are
30 condensed through a condensation coil back to a liquid. The liquid recovered is comprised of both solvent and water and the liquid is then passed through a separator in order to separate the two non-miscible liquids. The water may originate from the natural humidity of the ambient air

exposed to the textiles prior to cleaning. Another source of moisture may be materials used during pre-spotting.

5 Before textiles are removed from the machine, the washer becomes a dryer. Hot air is blown through the compartment but, instead of being vented outside, the air stream goes through a condenser that condenses the vapors to liquid. The liquid then passes through a separator to decant off the water from the solvent and return the solvent for reuse.

10 While various systems such as that set forth hereinabove have been developed for dry cleaning with solvents such as PERC, petroleum-based solvents, and hydrocarbons, none have been specifically tailored for use with a siloxane composition.

At step 2 the wash cycle is initiated with the solvent consisting of a combination of the tetramer and pentamer cyclic siloxane. The preferred combination is 80% tetramer and 20% pentamer by weight. In the alternative, the cyclic siloxane solvent may include any of the aforementioned combinations. The additives which modify the above mixture may be added separately just
5 before the washing cycle and need not be part of the solvent composition. The use of these additives, namely detergents and suspending agents, allows the solvent to perform a total garment cleaning process. The solvent and detergent (if used) is pumped from a holding tank into the cleaning basket. The items being cleaned are agitated, such that the mechanical rubbing of the clothes and the penetrating solvent dissolves and loosens dirt, debris and body fats from
10 the fabric fibers, said agitation lasting from 1 to 15 minutes. During the cleaning cycle, the solvent and the detergent mixture (if used) is pumped out of the basket through a "button trap" and then across a filter. The filter system helps to remove the particulate and impurities from the mixture. At times a choice of a "batch" solvent flow may be used wherein the mixture may not be exposed to the filter system, but be pumped from the button trap directly back to the
15 basket. In the alternative, any type of cartridge, discs, flex-tubular, rigid-tubular either individually or in combination. As yet another option, the filtration system further comprises either an additive such as carbon or diatomaceous earth.

At step 3 the items having been cleaned, the mixture is pumped from the basket to the working
20 tank or still and then the articles are centrifuged to remove as much mixture as possible and pump or gravity feed the remaining mixture to its destination. The centrifuging process lasts from 1 to 7 minutes depending on the articles and greater than 350 Revolutions Per Minute (RPM); preferably between 450 to 750 rpm. This operation leaves no more than 2-5%, or typically 3%, solvent residue in the items being cleaned. The higher the rpm, the faster the
25 solvent is removed by the centrifugal force of the spinning basket. The very low surface tension of the solvent maximizes the efficiency of solvent removal via this centrifugal process.

At steps 4 and 5 the garments are tumbled in the basket and heated to a temperature between 110 and 170 degrees Fahrenheit. The temperature is measured as the vapor-laden air exits the
30 cleaning basket at the pre-condensation point. The heating is accomplished by passing pressurized steam through a coil that heats up the air inside the basket through the use of a circulating fan. While this is happening, a partial vacuum can optionally be created inside the machine at negative pressure between 50 and 600 millimeters of mercury (where atmospheric

DESCRIPTION OF THE DRAWINGS

The aforementioned advantages of the present invention, as well as additional objects and advantages thereof, will be more fully understood hereinafter as a result of a detailed description
5 of a preferred embodiment when taken in conjunction with the following drawing in which:

Figure 1 is a schematic that represents a dry cleaning machine that is used with solvent that has a boiling point that requires vacuum distillation;

10 Figure 2 is a flow diagram indicating the steps of the method of dry cleaning in accordance with one embodiment of the present invention;

Figure 3 is a flow diagram indicating the functional steps of the method of separating water from the solvent; and
15

Figure 4 is a schematic that represents the mechanism used in separating water from solvent wherein the density of both are very close, as set forth in Figure 3.
20

DISCLOSURE OF THE INVENTION

The present invention includes an apparatus and method used in conjunction for the dry cleaning of fabrics, textiles, leathers and the like.

5

To perform the interrelated cleaning steps involving the present invention, a dry cleaning system 5 is shown schematically in Figure 1, although it is recognized that alternative cleaning configurations can be used. It should be noted that the cleaning system 5 of Figure 1 may be used for processing with a Class 3-A type solvent.

10

The dry cleaning of articles or other items begins by placing them in a horizontal rotating cleaning basket 10 of the system 5. The wash cycle is initiated with a dry cleaning fluid including an organo silicone-based siloxane solvent being pumped using a pump 12. The solvent is pumped from either a working tank 14, or a new solvent tank 16, and then to the cleaning basket 10 with the articles. The course of the pumped solvent can either be through a filter 18, or directly to the cleaning basket 10.

15

From the cleaning basket 10, the solvent is then circulated through the button trap 20 to the pump 12. After agitation for a predetermined amount of time, the solvent is drained and pumped to either of the three tanks 14, 16, and 22 shown in Figure 1. The cleaning basket 10 is then centrifuged in order to extract the remaining solvent to any of the tanks that is the desired.

20

The types of filtration systems compatible with the particular solvent of the present invention are: a spin disc of a 20 and 30 micron type with diatomaceous earth being capable of optional use with the 30 micron spin disc; a tubular filtration (flex, rigid, or bump) also being capable of optional use with diatomaceous earth; a cartridge (carbon core, all carbon or the standard size, jumbo or split size); and Kleen Rite cartridge system which results in no need for a still. Filters may also be used with a dimension between 10 to 100 microns to filter condensed vapors prior to separation.

25

30

The solvent may be filtered so as to eliminate the particulate soil that is released from the articles

being cleaned. Further, filtering of the silicone-based solvent eliminates the polymerization of the solvent even in the presence of catalysts.

5 The solvent being used for cleaning should be distilled at a rate of 10 to 20 gallons per hundred pounds cleaned, unless the aforementioned Kleen Rite cartridge system is being used. To accomplish this, a still 24 may be used to receive solvent from the filter 18, or from the dirty tank 22. The solvent in the dirty tank 22 can be introduced to the still through suction since the still is under a vacuum that is controlled by a float ball valve (not shown).

10 Any recovered or condensed vapors originating from the still may be condensed by water-cooled coils of a still vapor condenser 26. Thereafter, gravity urges the condensed solvent into a separator 28. The rate of flow, depending on the still, may range between .75 and 1.25 GPM, and the separator is engineered accordingly. Vacuum may be created by a liquid-head pump 30 or an evacuation process created by a venturi.

15 During the drying process, the articles are tumbled in the cleaning basket 10 with air being forced by a fan 32 over heating coils 34, which results in the incoming air flow to be between 120 and 180 degrees Fahrenheit. As the solvent and water remaining on the articles are heated and become vapor, the air flow exits the cleaning basket 10 and passes over cooling coils of a
20 drying vapor condenser 36 where the vapors condense back to a liquid. Gravity feeds such liquid to the separator 28 via a conduit 37.

The vapor laden air that leaves the cleaning basket 10 ranges in temperature between 120 and 138 degrees Fahrenheit. This temperature is important in that it is 30 degrees Fahrenheit or more
25 below the flash point of the aforementioned solvent. In one embodiment, the rate of flow of the condensed liquid may be limited to 0.75 GPM, and the separator may thus be engineered for the combined flow rate of condensed liquid from the still and drying vapor condensers 26 and 36.

30 Figure 2 illustrates an order in which the various components of the present invention may be employed for clarification purposes. Having followed the foregoing process of dry cleaning, there is no less than one but as many as two or more sources of solvent to the separator. The ability to return re-condensed solvent to the dry cleaning system is dependent on the separator 28 and its efficiency.

The hydrated solvent is then forced or pulled through coalescent media 64 positioned within the filter housing 62. This media is between 2 and 12 inches in diameter with a cross-section between 1/4 and 4 inches. It should be noted that there can be as many as three or more separate medium 64 positioned on the vertical cavity of the filter housing 62. The open cell configuration of a PFP polymer that may be used to construct the coalescent media 64 allows for the coalescing of the water micelles. Some of the water globules are created as the hydrated solvent is forced through the coalescent media 64 and appear on the outgoing side of the coalescent media 64.

The pump 60 may be electrical or pneumatic in form. The use of any flow controller such as the pump 60 or, in the alternative, a vacuum results in sufficient separation. The flow controller chosen should effect a flow of 0.5 to 2.5 GPM. If the inflow of hydrated solvent is greater than the coalescent media 64 will allow, the re-positioning of the float level switch 58 which activates the flow controller can be lowered to allow for a larger buffer for the hydrated solvent.

As the separated liquid leaves the filter housing 62, it enters a vertical tube 66 in another chamber 68 which allows the water globules to settle to a bottom thereof. The separated solvent flows out the solvent outlet 69.

The collected water globules at the base of the chamber 68 flow via gravity through the water gravity via a tube 70 to the bottom of the main chamber 48. In one embodiment, the line 70 has an inner diameter of between 1/8 and 1/4 inches. The water that is collected at the bottom of the main chamber 48 is evacuated by a water float level switch 72 which mechanically opens a hinged valve 74. There is also an option of using two conductivity points, or probes (not shown), that make contact as the water rises in order to complete a circuit to signal either a pneumatic or electric valve which may discharge the water that is in the main chamber 48. There may also be a manual drain at the bottom of the main chamber 48 for manual periodic maintenance.

The composition of the main chamber 48 can be stainless steel, or polyethylene. Constructing the main chamber 48 of carbon steel is discouraged since oxidation and rusting can quickly occur. Also, the use of tygon tubing, polyvinyl chloride, and vinyl chloride should be discouraged in that the silicone-based solvent will remove the plasticizer leaving the material brittle. Other products that are unaffected by the solvent may also be used.

The use of silicone-based solvent allows for latitudes in temperatures that have not traditionally existed in the dry cleaning field. The importance of controlling the temperature of the liquid solvents that are used in the field of dry cleaning is critical.

The most prevalent solvent used as previously stated is PERC whose temperature is ideally maintained at a range of 78 to 82 degrees Fahrenheit. This is also a common range for all other solvents currently being used in the field of dry cleaning. If the temperature should increase, the result is a much more aggressive solvent resulting in damage to textiles being processed. The increase in the KB (kari butyl) value most often results in causing dyes to be stripped from articles being cleaned, resulting in the transfer of these dyes to other articles being cleaned. The concern for controlling temperature has caused manufactures of dry cleaning machines to install water cooling coils placed in the base tanks, and in-line water cooling jackets on the plumbing lines for heat transfer.

By increasing the temperature of the silicone-based solvent of the present invention to a range of 90 to 130 degrees Fahrenheit, an aggressiveness in cleaning is afforded, without the result of pulling or stripping dyes. This is best accomplished by circulating water in a closed loop fashion between a hot water tank and through a circulating pump and through the coils (previously used for cooling) and back to the hot water tank. The circulating pump is controlled by a temperature probe that can be placed in the solvent. The result is precisely controlled solvent temperature which influences the aggressiveness of the solvent without causing damage to the articles being cleaned.

While various embodiments have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of a preferred embodiment should not be limited by any of the above described exemplary

embodiments, but should be defined only in accordance with the following claims and their equivalents.

CLAIMS

What is claimed is:

1. A system for dry cleaning articles comprising:
 - (a) a cleaning basket for receiving articles therein;
 - 5 (b) one or more tanks for containing a siloxane solvent;
 - (c) a pump coupled between the tank and the cleaning basket for immersing the articles in the cleaning basket with the siloxane solvent;
 - (d) a still for distilling the siloxane solvent to recover the siloxane solvent;
 - (e) a condenser coupled to at least one of the cleaning basket and the still for recovering
10 condensed vapors of the siloxane solvent;
 - (f) a separator coupled to the condenser for decanting any water in the siloxane solvent received from the condenser; and
 - (g) a fan coupled to the cleaning basket for circulating air past heater coils and into the cleaning basket for drying the articles.
- 15 2. The system recited in claim 1, wherein the still is coupled to the cleaning basket for receiving the siloxane solvent from the cleaning basket.
3. The system recited in claim 1, wherein the condenser is a still vapor condenser coupled to the still for recovering condensed vapors of the siloxane solvent from the still.
4. The system recited in claim 1, wherein the condenser is a drying vapor condenser
20 coupled to the cleaning basket for recovering condensed vapors of the siloxane solvent from the cleaning basket.
5. The system recited in claim 4, wherein a temperature of the vapor laden air from the cleaning basket is between 120 and 138 degrees Fahrenheit.
6. The system recited in claim 1, wherein the separator receives the siloxane solvent by way
25 of gravity.

7. The system recited in claim 1, wherein the still is coupled to the tank and a vacuum generator is coupled to the still for creating a vacuum therein which extracts the siloxane solvent therefrom.

8. The system recited in claim 1, wherein the circulating air is maintained between 120 and 180 degrees Fahrenheit.

9. A method of dry cleaning articles comprising the steps of:

- (a) loading the articles into a cleaning basket;
- (b) immersing the articles in a siloxane solvent;
- (c) agitating the articles in the siloxane solvent;
- (d) removing at least a portion of the siloxane solvent by centrifuging the articles;
- (e) distilling the siloxane solvent to recover the siloxane solvent;
- (f) recovering condensed vapors of the siloxane solvent;
- (g) separating any water in the siloxane solvent;
- (h) drying the articles by circulating heated air about the articles;
- (i) removing the articles from the cleaning basket; and
- (j) reusing the solvent.

10. The method recited in claim 9, wherein the distilled siloxane solvent is recovered through condensation.

11. The method recited in claim 9, wherein the condensed vapors of the siloxane solvent are recovered from the still.

12. The method recited in claim 9, wherein the condensed vapors of the siloxane solvent are recovered from the cleaning basket.

13. The method recited in claim 12, wherein a temperature of the condensed vapor laden air from the cleaning basket is between 120 and 138 degrees Fahrenheit.

14. The method recited in claim 9, and further comprising the step of using a vacuum generator to extract the siloxane solvent from a still used to distill the siloxane solvent.

15. The method recited in claim 9, wherein the circulating heated air is maintained between 120 and 180 degrees Fahrenheit.
16. The method recited in claim 9, and further comprising the step of filtering the siloxane solvent prior to immersing the articles.
- 5 17. The method recited in claim 9, and further comprising the step of filtering the siloxane solvent prior to recovery of the siloxane solvent.
18. The method recited in claim 9, and further comprising the step of maintaining a temperature of the siloxane solvent used during agitation between 90 and 130 degrees Fahrenheit.
- 10 19. The method recited in claim 9, wherein a coalescing media comprised of open cellular foam as prepared by urea-formaldehyde resin is utilized to enhance the dry cleaning process.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/15923

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3739711 A	08-06-1989	NONE	
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5. The system recited in claim 4, where in a temperature of vapor laden air from the cleaning basket is between 120 and 138 degrees Fahrenheit.
6. The system recited in claim 1, wherein the separator receives the siloxane solvent by way of gravity.
7. The system recited in claim 1, wherein the still is coupled to the tank and a vacuum generator is coupled to the still for creating a vacuum therein which extracts the siloxane solvent therefrom.
8. The system recited in claim 1, wherein the circulating air is maintained between 120 and 180 degrees Fahrenheit.
9. A method of dry cleaning articles using siloxane solvent and no added volatile organic cleaning solvents comprising the steps of:
 - (a) loading the articles into a cleaning basket;
 - (b) immersing the articles in a siloxane solvent;
 - (c) agitating the articles in the siloxane solvent;
 - (d) removing at least a portion of the siloxane solvent by centrifuging the articles;
 - (e) distilling the siloxane solvent to recover the siloxane solvent;
 - (f) recovering condensed vapors of the siloxane solvent;
 - (g) separating any water in the siloxane solvent;
 - (h) drying the articles by circulating heated air about the articles;
 - (i) removing the articles from the cleaning basket; and
 - (j) reusing the solvent.

10. The method recited in claim 9, wherein the distilled siloxane solvent is recovered through condensation.
11. The method recited in claim 9, wherein the condensed vapors of the siloxane solvent are recovered from the still.
- 5 12. The method recited in claim 9, wherein the condensed vapors of the siloxane solvent are recovered from the cleaning basket.
13. The method recited in claim 12, wherein a temperature of condensed vapor laden air from the cleaning basket is between 120 and 138 degrees Fahrenheit.
14. The method recited in claim 9, and further comprising the step of using a vacuum generator to extract the siloxane solvent from a still used to distill the siloxane solvent.
15. The method recited in claim 9, wherein the circulating heated air is maintained between 120 and 180 degrees Fahrenheit.
16. The method recited in claim 9, and further comprising the step of filtering the siloxane solvent prior to immersing the articles.
17. The method recited in claim 9, and further comprising the step of filtering the siloxane solvent prior to recovery of the siloxane solvent.
18. The method recited in claim 9, and further comprising the step of maintaining a temperature of the siloxane solvent used during agitation between 90 and 130 degrees Fahrenheit.
19. The method recited in claim 9, wherein a coalescing media comprised of open cellular foam as prepared from urea-formaldehyde resin is utilized to enhance the dry cleaning process.

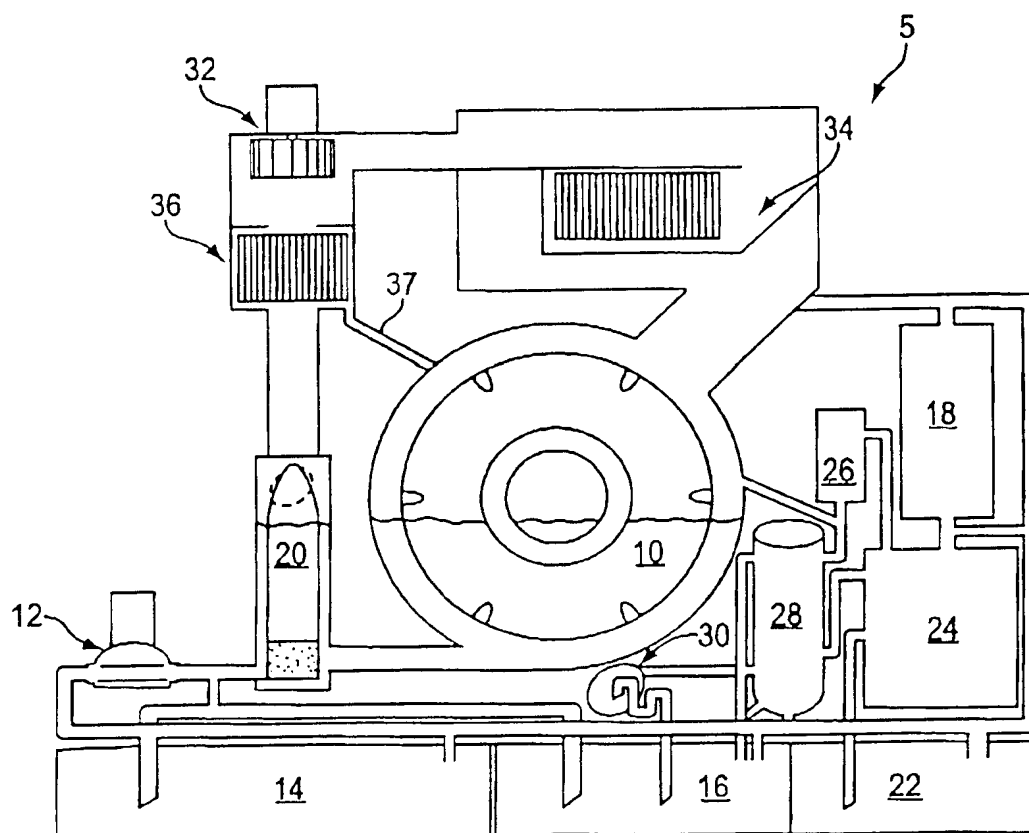


FIG. 1

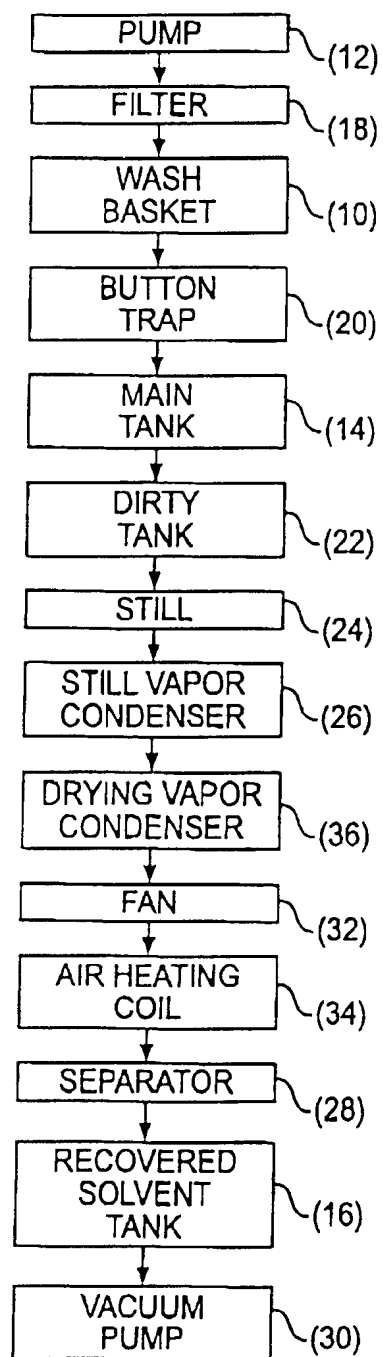


FIG. 2

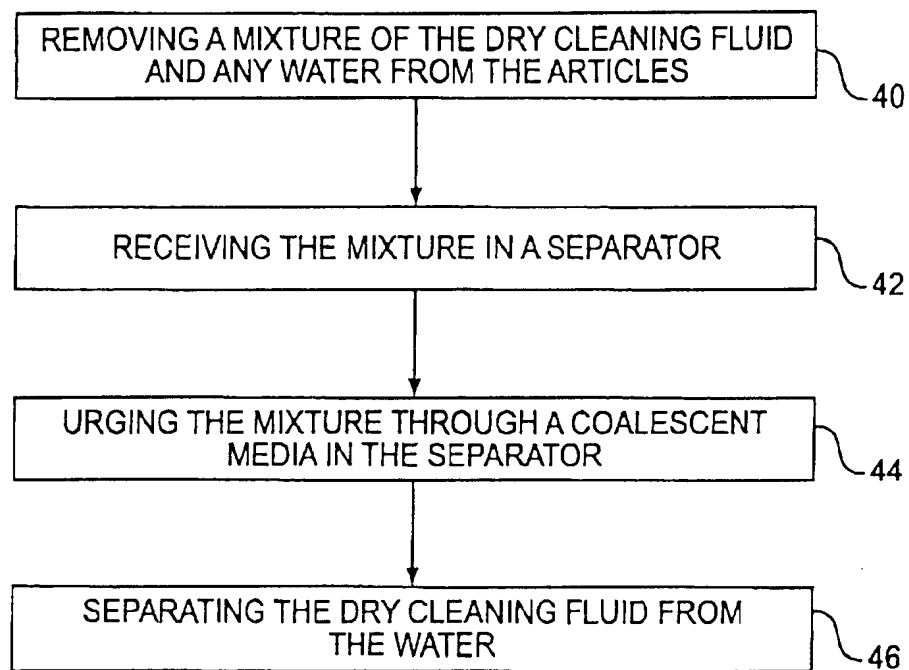


FIG. 3

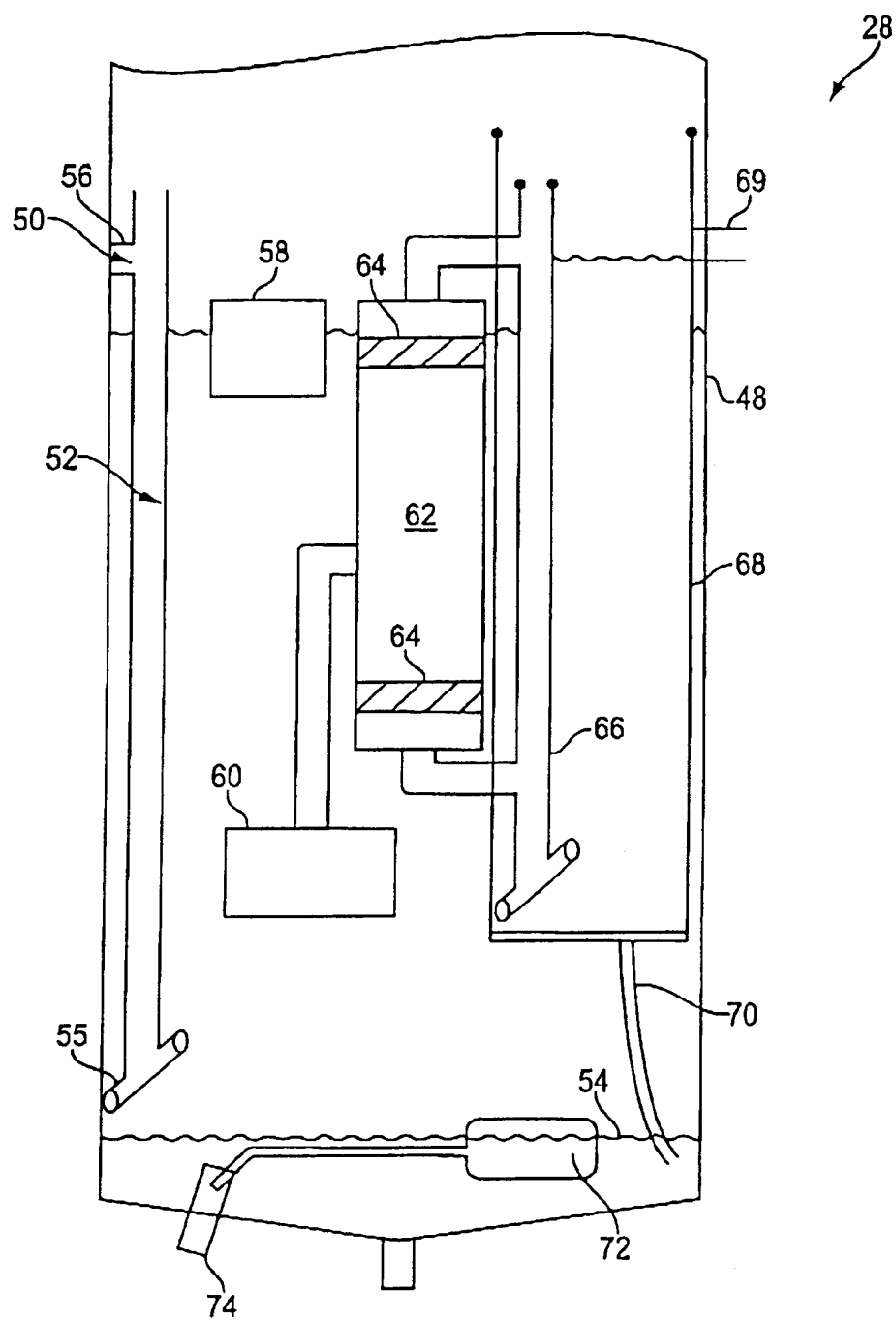


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/19255

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : D06L 1/08; D06F 43/08

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 8/142, 137, 159, 141; 68/18C, 20, 18F, 18R, 18FA, 19.2, 23R, 23.5, 24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

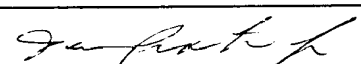
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 4,712,392 A (HAGIWARA et al) 15 December 1987, col. 5, line 15 through col. 6, line 37; and Figure 1.	1-8
----- A		----- 9-19
A	US 3,123,494 A (CHARREAU) 03 March 1964.	1-19
A	DE 3,739,711 A1 (HASENCLEVER) 08 June 1989.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 23 AUGUST 2000	Date of mailing of the international search report 20 SEP 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer  ALAN D. DIAMOND Telephone No. (703) 308-0661

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/19255

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

8/142, 137, 159, 141; 68/18C, 20, 18F, 18R, 18FA, 19.2, 23R, 23.5, 24